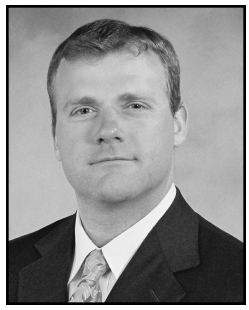
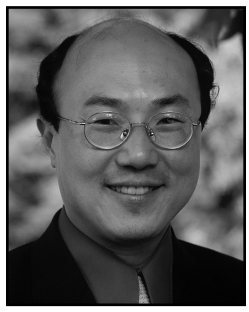
E2 Digital RF – Fundamentally a New Technology or Just Marketing Hype?





Organizers: Chris Rudell, *Intel, Santa Clara, CA*
Qiuting Huang, *ETH Zurich, Zurich, Switzerland*

Moderator: Thomas Lee, *Stanford University, Stanford, CA*

Recent publications have lauded the benefits of new, highly-integrated transceiver systems which appear to realize receive and transmit paths using all digital electronics. These all-digital radios might radically reduce power consumption and die area, in addition to scaling more gracefully from process node to process node than traditional analog solutions. Have we reached a fundamental milestone in the evolution of mixed-signal electronics? Or has much recent attention merely been given to what all IC designers have known from day one… the more digital, the better! These radios hold the promise of being made programmable for operation on different RF standards. However, have the recently published digital implementations traded away too much performance and are the digital signal processing techniques used too standards-specific? In short, have recent publications added a bit of hyperbole to the novelty of implementing RF transceivers exclusively with digital logic, or is this a watershed achievement in the history of analog and mixed-signal electronics? A group of six distinguished panelist will debate the meaning and impact of "Digital RF."

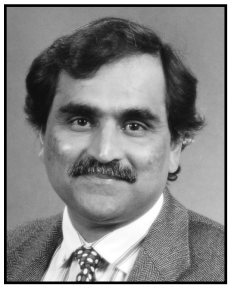
Panelist Statements:

SDR: Once Object of Derision, Real Today with Digital RF
Asad Abidi, University of California, Los Angeles, CA
The wireless transceiver is undergoing a revolution. The last revolution gave rise to the single-chip transceiver. Its salient features were the widespread use of direct conversion in the receiver, and a complex signal processing path. Otherwise the use of analog and digital circuits represented the mixed-signal state-of-the-art at the time.

What is new this time around is building the transceiver from the ground up assuming that DSP power is practically unlimited and free, and that the radio architecture must exploit this to the fullest. A strong penalty is associated with relying too much on analog circuits, which must be kept to a bare minimum. This brings flexibility and portability to realizations in deep submicron CMOS. Of course the circuits at the antenna must be analog (LNAs, PAs), and these require more design skill than ever before.

With concepts such as early sampling and outphasing modulation, we see the prevalence of discrete-time multi-rate signal processing and binary (digital) circuits. They afford an unprecedented flexibility that is truly independent of specific standards, and lead to the much sought after software-defined radio.

Digital High Frequency or High Frequency Marketing?
Rudolf Koch, Infineon, Minich, Germany
Current trends of multi-band multi-standard phones and upcoming standards with variable bandwidth like 3.9G or WiMax require ever more multi-use ability and flexibility from the RF blocks, i.e. digital control and programmability. SoC integration requires deep submicron CMOS implementations where analog deficiencies need calibration and compensation, again under digital control. With a flexible ADC close to the mixer the analog component count is reduced and, e.g., sampled data filters become obsolete. So the digital content of RF transceivers is increasing, and digital friendly concepts for the remaining RF and analog blocks are a must - but a really "digital RF" does not and will not exist.



Digital Techniques will Improve Multi Comm Integrated Circuits
Krishnamurthy Soumyanath, Intel, Hillsboro, OR
When Pablo Picasso first saw the brilliant cave paintings of prehistoric humans, he is reported to have said "We have invented nothing". If radio pioneer Armstrong were reviewing today's RFIC designs he would doubtless echo this sentiment. These traditional (100 year old) architectures have served us well so far but are rapidly becoming boat anchors that inhibit scaling and flexibility. Clearly there will always be a core analog element in all transceivers, but the dominant mechanism of impairment reduction will be DSP based. Technologies developed for over sampled ADC's move naturally to various parts of the receiver chain. Innovations in the transmitter, switching PA's and synthesizer will also flow from the availability of high speed time domain processing. The results are lower cost, faster time to market and increased flexibility for multi-comm. solutions.

Winning Recipe: Digital Turns RF and RF Turns Digital
R. Bogdan Staszewski, Texas Instruments, Dallas, TX
I am not sure whether the digital versus analog (or RF) dichotomy is valid anymore. In the good old days, the separation was clear but now we see lots of cross-pollination. Design of (high-speed) digital circuits requires good analog skills for ground bounce, cross-talk, decoupling, etc. Likewise, analog circuits (in nanometer scale CMOS) are becoming less useful alone and require lots of digital assistance. The digital RF design as I know is thus: It is often difficult to separate digital from analog or RF. However, the nature of RF is no longer the same. For the integration to make economic sense, the designer's mindset must be turned away from the traditional RF circuits in favor of digital architectures. The integration law is immutable: Once it is accomplished there is no turning back! It has already happened in hard-disk drives and ADSL modems.

Fusion of standard RF Analog and Digital are Essential for Future RF LSI
Satoshi Tanaka, Hitachi, Tokyo, Japan
Fully digital RF would mean direct digital conversion of RF analog signals. However, it is difficult to achieve both wide dynamic range and wide bandwidth at the same time with this methodology. Realistic multi-mode transceiver will be possible by, for example, a direct down and up conversion architecture. It will require at least LNA, driver amplifier, mixers and some LPFs with precise ADCs and DACs. It is true that addition of digital signal processing is effective in achieving precise analog characteristics and that truly higher integration of RF and digital signal processing into a single chip is a big trend. However, "Digital RF" is too much an exaggerated description. Standard RF analog circuits will keep their importance in the future as they are at present.

Some Assembly Required
David Welland, Silicon Laboratories, Austin, TX
Gone are the days, by and large, of purely analog transceivers. Mixed-signal architectures reign, exploiting analog, digital, and signal processing technologies. But has this shift changed—or will it someday soon change—the nature of the design and manufacture of these devices? Even with the availability of piles of cheap, scalable, digital transistors, it is my contention that the most challenging aspects of radio design remain as they have since the beginnings of radio communications: Namely those regarding front end amplifiers and RF oscillators. Indeed, while other radio circuit blocks may benefit from the application of digital techniques, the design of LNAs and VCOs can actually be rendered more difficult by the presence of nearby digital activity. The era of digitally *assisted* RF may be upon us, but as for digital RF, its practitioners must still retain the old skills.